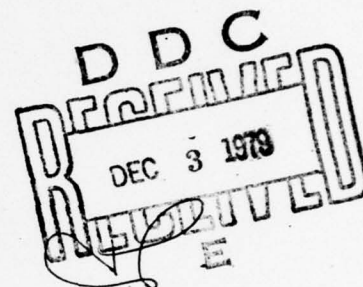Research Problem Review 78-11

LEVEL II

NET ASSESSMENT OF TANK CREW TRAINING

AN ANALYSIS OF COMPANY TANK CREW GUNNERY SCORES

William K. Earl
Operations Research Associates

FORT HOOD FIELD UNIT

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U. S. Army

Research Institute for the Behavioral and Social Sciences

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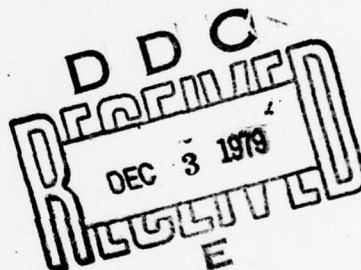
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the
Deputy Chief of Staff for Personnel

JOSEPH ZEIDNER
Technical Director (Designate)

WILLIAM L. HAUSER
Colonel, US Army
Commander

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Research Problem Review 78-11

NET ASSESSMENT OF TANK CREW TRAINING:

AN ANALYSIS OF COMPANY TANK CREW GUNNERY SCORES

William K. Earl, Ph.D.
Operations Research Associates

ARI FIELD UNIT AT FORT HOOD, TEXAS

August 1978

Submitted as complete and
technically accurate, by
George M. Gividen
Field Unit Chief

Approved by:

A. H. Birnbaum, Acting Director
Organizations and Systems Research
    Laboratory

Joseph Zeidner
Technical Director (Designate)
U.S. Army Research Institute for the
Behavioral and Social Sciences

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LIST OF FIGURES

This report is provided as input for the overall Department of Defense net assessment study of U.S. and Soviet tank crew training. It will be incorporated into Chapter 2 of the MASSTER report "Assessment of Tank Crew Training" as Section 2-3b(4). To facilitate incorporation without additional revisions, the paragraphs and figures have been numbered as they will appear in the final MASSTER report (e.g., the first figure in this report is designated as Figure 2-13, rather than Figure 1, since it will be the thirteenth figure of Chapter 2 in the MASSTER report; the first paragraph is designated 2-3b(4) since that will be its corresponding paragraph number in the MASSTER report). ~~Some of the research was accomplished by Operations Research Associates under contract DAHC 19-75-C-0017.~~ This report consists of a description of the experimental crews in terms of their overall gunnery qualification scores, and a presentation of the analyses of company tank crew data across a variety of variables using several different analytical methodologies.

JOSEPH ZEIDNER
Technical Director (Designate)

AN ANALYSIS OF COMPANY TANK CREW GUNNERY SCORES

BRIEF

Requirement:

This report was prepared in response to a request by the Training Developments Branch of the Operations and Plans Division, HQ MASSTER, Fort Hood, Texas. The research was designed to fulfill a requirement for the collection, analysis and reporting of tank crew gunnery score data. The research was required as input to the TRADOC report Net Assessment of U.S. and Soviet Tank Crew Training. The objective was to provide an initial tank crew training data base and an analysis of this data base to provide information relating to differences in gunnery performance as a function of company effects when training was held constant.

Procedure:

Tank crews of three companies of a 1st Cavalry Division M60A1 tank battalion received a standardized gunnery training program. Table VIII gunnery data for these tank crews was then collected. Main gun gunnery scores were compared (analysis of variance) for the tank companies for both day and night firings, and for both number of hits and firing times required.

Principal Findings:

● Companies receiving standardized gunnery training programs differed significantly ($p < .01$) from each other in mean number of targets hit by tank crews on Table VIII qualification firings.

● Companies receiving standardized gunnery training programs differed significantly ($p < .001$) from each other in tank crew mean firing times on Table VIII qualification firings.

● When tank crew gunnery training was standardized and held constant across companies, the mean tank crew gunnery performance of companies differed significantly from each other as a function of company effects. The precise nature of these effects is not known and should be the basis for further research.

Utilization of Findings:

These findings will be incorporated into the TRADOC report Net Assessment of U.S. and Soviet Tank Crew Training and will be used as a basis for the design of follow-on research.

AN ANALYSIS OF COMPANY TANK CREW GUNNERY SCORES

*2-3b(4) A profile by average score and points lost is shown in figure
2-13. The average scores are for the 53 tank crews who completed both day
and night qualification firing; one crew was disqualified during the day
run and the partial score was not included in all subsequent analyses. For
the test battalion, 41 crews qualified (21 distinguished) and 13 crews were
unqualified, based upon the total scores of both day and night, as the
criterion for qualification, only 25 crews qualified (21 distinguished)
and 29 crews were unqualified. Of those crews failing to qualify under
this criterion, 75.86 percent were unqualified on VIII A and 51.72 percent
were unqualified on VIII B. Only 8 crews failed to qualify for both day
and night qualification tables. Within the battalion, there was little
correlation between day and night scores (r =.35), and high correlation
(as expected) between day and total scores (r =.77) and night and total
scores (r =.87). This analysis indicates that for this unit, the night
scores were a better indicator of each individual crew's overall per-
formance. The average points lost reflect the increased importance
placed by the battalion on speed and accuracy for all engagements. The
total points received versus a time scale for all main gun and machinegun
engagements, day and night, is shown in figure 2-14. The increased
allowable times for night engagements significantly lowered the average
points cut (-51 percent), whereas accuracy and crew duty points lost
remained stable or had minimal effect on total scores. The profiles

*For explanation of paragraph numbering rationale in this report, see
 FOREW RD.

		Score			Average points lost		
	Max	Min	Average	Time	Accuracy	Crew Duty
TOTAL	(1200)	(840)		(510)	(550)	(140)
Bn			923	91	176	10
A			992	66	130	12
B			828	108	254	10
C			933	107	151	9
H			1040	40	116	4
Top 6 tanks			1118	24	52	6
Bottom 6 tanks			662	193	319	26
Day	(550)	(385)		(230)	(250)	(70)
Bn			400	61	87	2
A			440	40	68	2
B			340	72	135	3
C			417	73	58	2
H			429	40	81	0
Top 6 tanks			499	19	31	1
Bottom 6 tanks			276	105	165	4
Night	(650)	(455)		(280)	(300)	(70)
Bn			523	30	89	8
A			552	26	62	10
B			488	36	119	7
C			516	34	93	7
H			611	0	35	4
Top 6 tanks			619	5	21	5
Bottom 6 tanks			386	88	154	22

Figure 2-13 (U). Profile by average score and points lost (U).

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POINT/AREA MG   SUPPRESSION MG

20 Point Scale   10 Point Scale

(Night) 10 - - - - - - 15 - seconds - - 20   (Night) 10 - - - - - - -15 - seconds - - 20

(Day) 5------------10-------------15   (Day) 5---------------10--------------15

    6 7 8 9   11 12 13 14   6 7 8 9   11 12 13 14

   19 18 17 16   12 9 6 3   9   8   6 4 2 1

20------------15---points-------0   10-------------7----points------0

Battle sight Day (Night)

80   70   45   0 POINTS

    78 76 74 72   65 60 55 50   40 30 20 10
     6 7 8 9   11 12 13 14   16 17 18 19

(Day) 5   10   15   20 SECONDS

(Night)10 - - - - - - -15- - - - - - - 20 - - - - - - - 25

Precision Engagement Day (Night)

80   70   50   30   0 PTS

    78 76 74 72   66 62 58 54   46 42 38 34   24 18 12 6
    11 12 13 14   16 17 18 19   21 22 23 24   26 27 28 29

(Day) 10   15   20   25   30 SEC

(Night)15   20   25   30   35

Figure 2-14 (U). Points versus time scale used during tank gunnery qualification firing (U)

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	1	2	3	4	5	6	7	8	9	Total	Total (w/o exercise)
Possible	50	100	100	50	50	(100)	100	50	50	650	550
Bn	48	55	68	46	47	(21)	40	47	48	420	399
A	47	63	88	44	48	(28)	54	50	47	469	441
B	48	42	36	45	46	(22)	29	47	49	364	342
C	50	53	79	47	49	(14)	45	45	49	431	417
H	44	100	86	50	50	(18)	0	50	49	447	429
Top 6 Tanks	47	77	94	46	50	(68)	76	50	46	554	486
Bottom 6 Tanks	46	15	18	43	49	(0)	20	49	46	286	286
w/o exercise 6 Day (4 of the original 6 tanks in each group changed)											
Top 6 Tanks	48	72	94	45	48	–	94	50	49	500	
Bottom 6 Tanks	47	18	2	43	49	–	28	44	46	277	

Figure 2-15 (U). Profile by firing exercise (day) (U).

	1	2	3	4	5	6	7	8	9	Total
Possible	50	100	100	100	50	50	100	50	50	650
Bn	48	81	81	71	47	48	51	47	48	522
A	48	90	88	74	44	47	69	46	45	551
B	48	66	75	60	48	49	45	48	49	488
C	48	85	80	75	49	48	35	46	49	515
H	43	99	87	100	50	50	85	47	50	611
Top 6 Tanks	50	100	97	90	49	48	97	50	44	625
Bottom 6 Tanks	48	30	62	37	38	42	18	46	39	360
w/o exercise 6 Day (4 of the original 6 tanks in each group changed)										
Top 6 Tanks	50	100	93	89	49	48	93	50	47	619
Bottom 6 Tanks	47	50	68	41	40	43	10	47	41	387

Figure 2-16 (U). Profile by firing exercise (night) (U).

of average scores by firing exercises, both day and night, are reflected in Figure 2-15 and 2-16, respectively. The main gun targets had the greatest impact on total scores. During day qualification, an average of 54.3 percent of the total possible main gun target points were received on exercises 2, 3, and 7; while at night, an average of 71 percent of the total possible main gun target points were received on exercises 2, 3, 4, and 7. For all machinegun targets, average of 94.4 percent of the day and 95.2 percent of the night total possible points were received. Additional statistical analysis of gunnery data for the test battalion is discussed in detail as follows:

(a) The company tank crew gunnery scores for the subcaliber targets and main gun targets 2, 3, and 7 were analyzed in an analysis of variance. The moving target engagements (exercise 6 day and 4 night) were excluded from this analysis. A summary of the results are presented in Figure 2-17. The main effect (difference between companies) was statistically significant $[F(2, 48) = 7.83, p < .01;]$. The main effect of Table VIII was also significant $[F(1, 48) = 15.52, p < .001]$, while the interaction effect of companies and Table VIII was not significant. A Tukey's (HSD) Test of the difference between companies indicated that gunnery scores for Company B, 767, were significantly less ($p < .01$) than gunnery scores for both Company A, 917, and Company C, 859. These scores are presented in Figure 2-18. The Table VIII gunnery scores for Companies A, B, and C for Table VIII B, 449, were significantly greater than their gunnery scores for Table VIII A, 399.

(b) A summary of the analysis of variance for hits on main gun targets for tank crews is presented in Figure 2-19. The results indicate that the main effects of companies $F(2, 48) = 3.40, p < .05$, and Table VIII $F(2, 48) = 61.10$,

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Source of variance	SS	df	MS	F	P
Between Tank Crews	396,931	50			
A-Companies	97,624	2	48,812	7.83	<.01
Tank crews within groups (error)	299,307	48	6,236		
Within Tank Crews	279,725	51			
B-Table VIII	63,900	1	63,900	15.52	<.001
AB-Companies X Table VIII	18,160	2	9,080	2.21	NS*
B X tank crews within groups (error)	197,665	48	4,118		

* not significant

Figure 2-17 (U). Analysis of variance of gunnery scores (subcaliber and main gun targets 2, 3, and 7) (U).
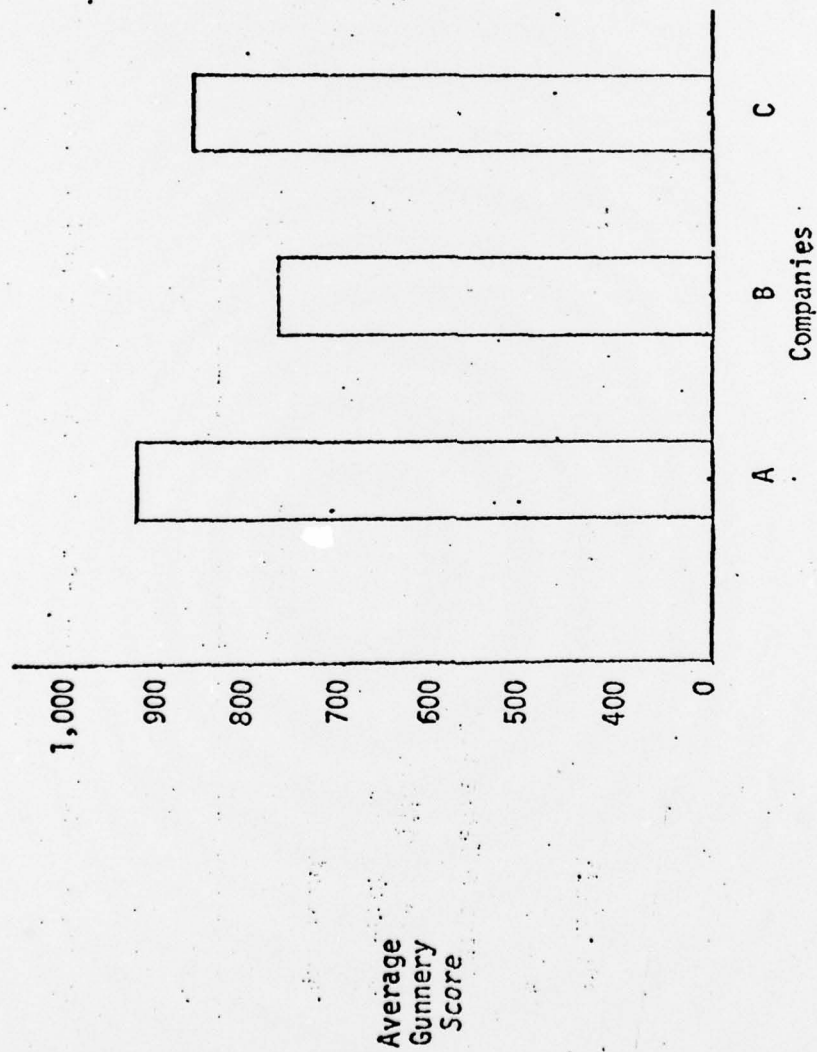
Figure 2-18 (U). Companies Main Effect $F_{.01}$ (2, 48) = 7.83, $p < .01$ (U).

Source of variance	SS	df	MS	F	P
Between Tank Crews	161	50			
A-Companies	20	2	10,000	3.40	<.05
Tank crews within groups (error)	141	48	2,938		
Within Tank Crews	182	51			
B-Table VIII	98	1	98,000	61.10	<.001
AB-Companies X Table VIII	7	2	3,500	2.18	NS*
B X tank crews within groups (error)	77	48	1,604		
Total	343	107			

* not significant

Figure 2-19 (U). Analysis of variance of total number of hits on main gun targets 2, 3, 4 or 6, and 7 (U).

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p $<$.001, were statistically significant, while the interaction effect of companies and Table VIII was not significant. A Tukey's (HSD) Test of the companies' main effect indicated that the average number of main gun target hits for the tank crews in Company B, which was 8.71, was significantly less, p $<$.01, than the average number of hits for the tank crews in Company A, which was 10.82. A total possible score was 16. The company scores are presented graphically in figure 2-20. The main effect for Table VIII indicated that the average number of main gun hits for each tank crew on Table VIII B (night), which was 5.86, was significantly greater than the average number of hits obtained on Table VIII A (day), which was 3.90.

(c) The amount of mutual interrelationship between gunnery scores and number of main gun target hits (accuracy score) was estimated by computing the coefficient of correlation between the scores of the two variables. The results produced a value of r=0.8446 which is a highly positive correlation that is statistically significant at the .001 level of confidence. The coefficient of determination r^2 = 0.7133 indicates that 71 percent of the gunnery score is determined by the value of the corresponding target accuracy score. Thus the two scores are highly similar and seem to be equivalent measures of the same performance. A graphic illustration of the correlation is presented in figure 2-21. The regression line in figure 2-21 shows that a small gunnery score will be associated with a small accuracy score while a large gunnery score will be associated with a large accuracy score.

(d) The firing times on the main gun targets 2, 3, and 7 for the company tank crews were calculated and analyzed as follows. The firing
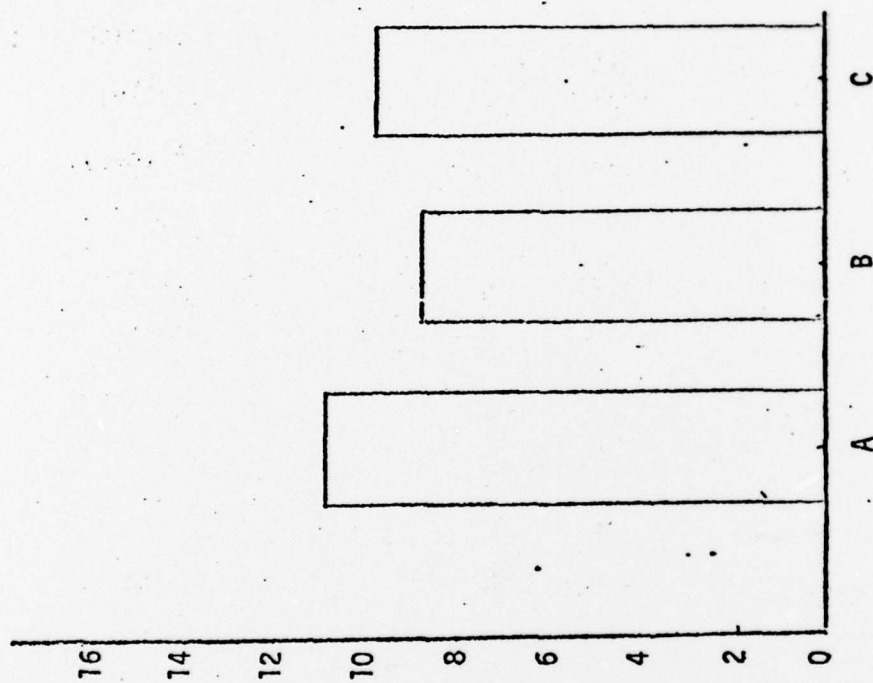
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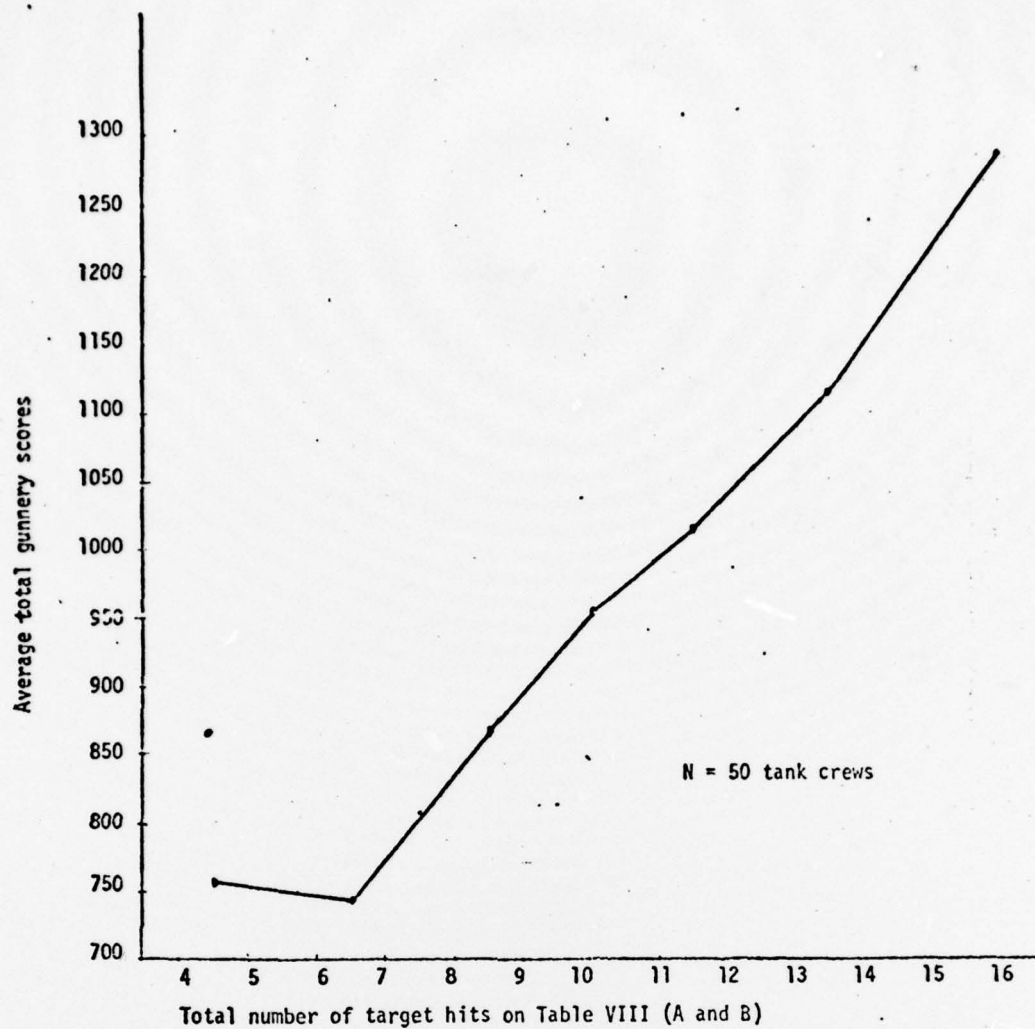Figure 2-20 (U).   Companies · main effect F (2, 48) = 3.40, p < .05 (U).

Figure 2-21 (U). Correlation between total number of main gun target hits on Table VIII (A and B) and total gunnery scores (r= .845, p<.001) (U).

Source of variance	SS	df	MS	F	P
Between Tank Crews	2,015	50			
A – Companies	543	2	272	8.77	<.001
Error (a)	1,472	48	31		
Within Tank Crews	16,840	561			
B – Table VIII	1,113	1	1,113	46.38	<.001
AB – Companies X Table VIII	173	2	87	3.63	<.05
Error (b)	1,146	48	24		
C – Rounds	1,599	1	1,599	55.14	<.001
AC – Companies X rounds	310	2	155	5.35	<.01
Error (c)	1,413	48	29		
BC – Table VIII x rounds	1	1	1	--	N.S.
ABC – Companies X Table VIII x rounds	55	2	28	1.17	N.S.
Error (bc)	11,030	456	24		

Figure 2-22 (U). Analysis of variance of firing time on main-gun targets 2, 3, and 7 (U).

time for the first round was calculated by measuring the elapsed time between the time at target identification and the time when the first round was fired. The firing time for the second round was calculated by measuring the elapsed time between the time when the first round was fired and the time when the second round was fired. The firing times were analyzed in a three-factor analysis of variance measuring the effects of companies, Table VIII (day versus night), and rounds (first and second) on average firing time. Figure 2-22 presents a summary of the results. The results indicate that statistically significant main effects were companies $F(2,48) = 8.77$, $p < .001$; Table VIII $F(1,48) = 46.38$, $p < .001$; and rounds $F(1, 48) = 55.14$, $p < .001$. Statistically significant interaction effects were companies and Table VIII $F(2, 48) = 3.63$, $p < .05$; and companies and rounds $F(2, 48) = 5.35$, $p < .01$. The overall mean (average) firing times for the companies are presented in figure 2-23(A). A Tukey's (HSD) Test of the companies main effect indicated that the mean firing times for Companies A and C were significantly faster than the mean firing time for Company B.

(A) Companies

Company	Mean (average) firing time
A	8.20 seconds
C	8.71 seconds
B	10.40 seconds

(B) Table VIII

	Mean firing time
Table VIII A (day)	7.75 seconds
Table VIII B (Night)	10.45 seconds

Figure 2-23 (cont) (U). Mean firing scores for the main effects (U).

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```
         (C)  Main gun rounds

                      Mean firing time
     1st round             7.49 seconds
     2d round             10.71 seconds
```

Figure 2-23 (cont) (U). Mean firing scores for the main effects (U).

Figure 2-23(B) presents the mean firing times for all tank crews on Table
VIII A and Table VIII B. The values indicate that the mean firing time
for the tank crews was significantly faster during the day course than
during the night course. Figure 2-23(C) presents the mean firing times
for all tank crews on the first round and second round for all targets
day and night. The values indicate that the tank crews fired the first
round significantly faster than the second round. The companies and Table
VIII interaction was analyzed by a Tukey's (HSD) Test and the mean
scores are presented in figure 2-24.

```
                                    Table VIII
     Company        A (day)             B (night)
        A          7.38 seconds         9.02 seconds
        B          9.25 seconds        11.55 seconds
        C          6.63 seconds        10.78 seconds
```

Figure 2-24 (U). Companies and Table VIII interaction mean firing times (U).

The results revealed that, for a within-company comparison, the mean
firing times for Companies B and C were significantly faster during the
day than during the night $(p < .01)$, while there was no significant
difference in the mean firng scores for Company A. Between-company comparisons
revealed that the mean firing time for Company C during the day, 6.63
seconds, was significantly faster than the mean firing time for Company
B during the day, 9.25 seconds $(p < .01)$. The companies and rounds
interaction was analyzed by a Tukey's (HSD) Test and the mean firing scores

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are presented in figure 2-25.

Company	Rounds	
	1st Round	2d Round
A	5.58 seconds	10.82 seconds
B	9.24 seconds	11.75 seconds
C	7.65 seconds	9.77 seconds

Figure 2-25 (U). Companies and rounds interaction mean firing times (U).

Analysis of the within-company comparisons revealed that the mean firing times (day and night) for Companies A and B for the first round was significantly faster than their mean firing times for the second round ($p < .01$), while there was no significant difference between the mean firing times for Company C on the first and second round. Between-company comparisons revealed that the mean firing time for Company A on the first round, 5.58 seconds, was significantly faster than the mean firing time for Company B on the first round, 9.24 seconds ($p < .01$).

(e) The relationship between firing times and accuracy scores (percent of target hits) was estimated by computing a point-biserial coefficient of correlation between the measures for each target on Table VIII A and Table VIII B for a total of 14 comparisons. None of the 14 point-biserial correlation values were statistically significant. The results indicated that main gun accuracy for the first and second rounds is not influenced by firing time. Figures 2-26 and 2-27 present plots of accuracy scores for firing times at 2 second time intervals. The functions are basically flat across the firing times falling in the general area of 70 to 80 percent accuracy. Thus the plots show that main gun accuracy remained about 70 to 80 percent regardless of what the firing time was; 1.5 to 17.5 seconds. One interpretation of these
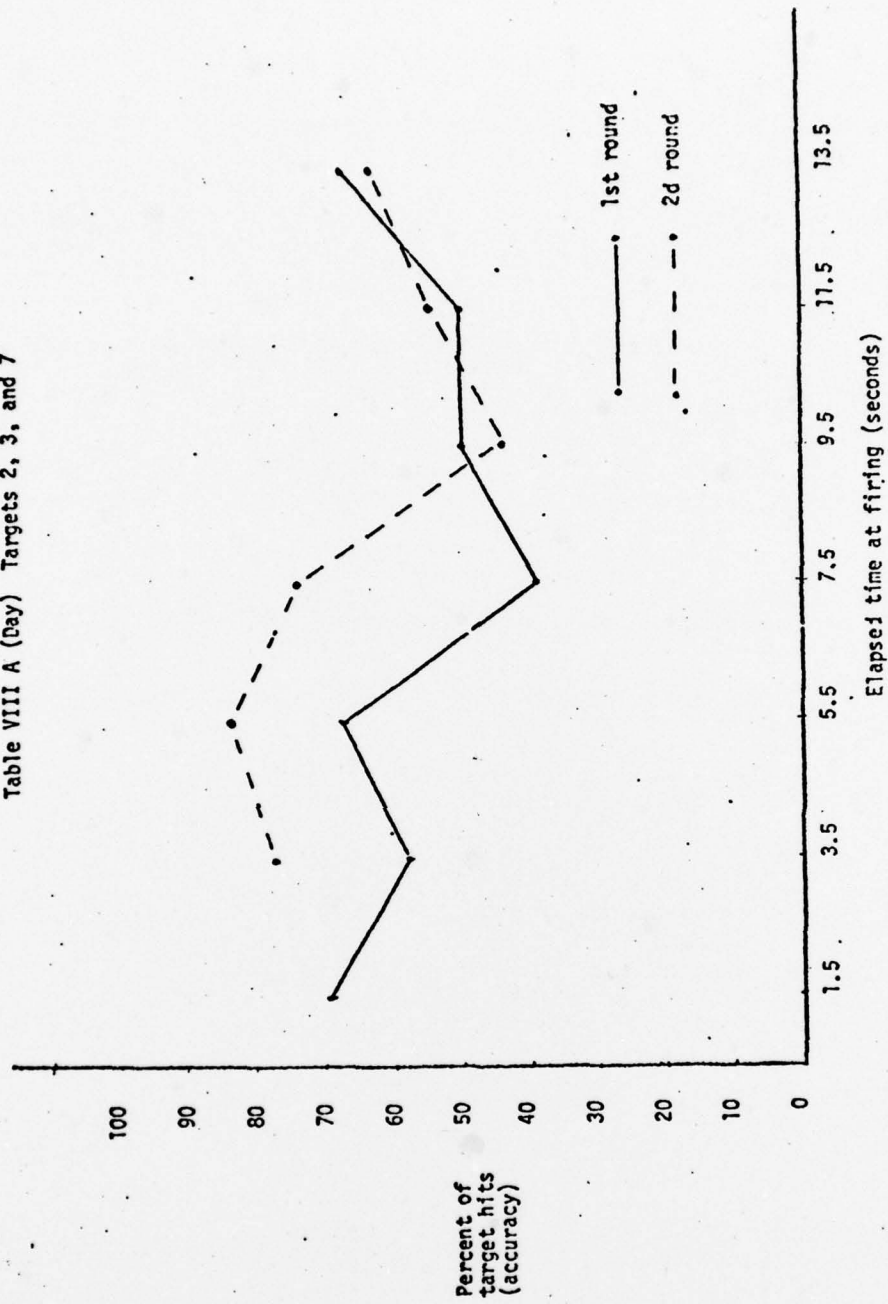
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Table VIII A (Day) Targets 2, 3, and 7

Figure 2-2G (U). Main gun gunnery accuracy as a function of elapsed time to fire after target detection by the tank commander (U).

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Table VIII B (Night) Targets 2, 3, 4, and 7

Percent
of target
hits
(accuracy)
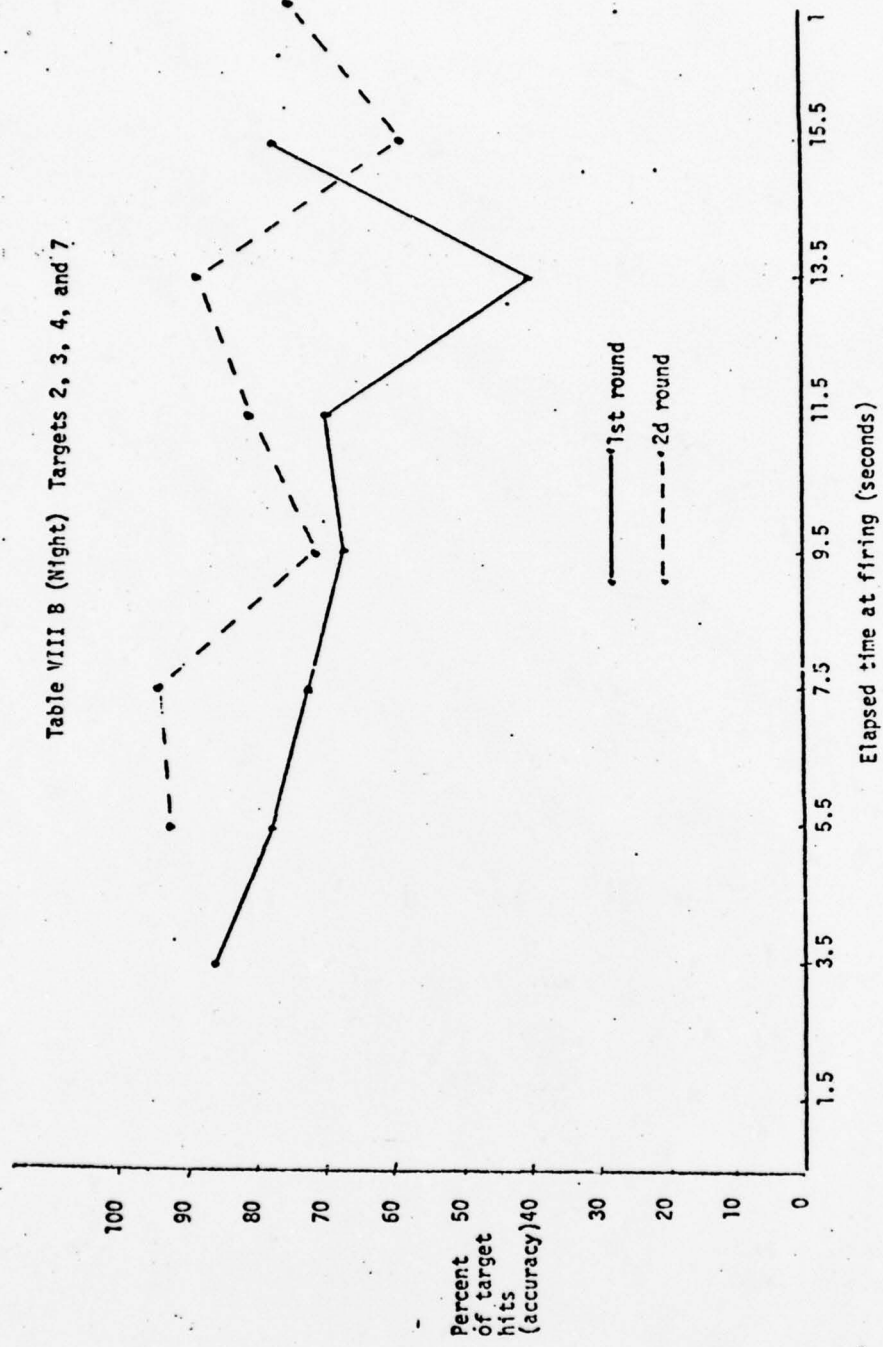
Elapsed time at firing (seconds)

1st round
2d round

Figure 2-27 (U). Main gun gunnery accuracy as a function of elapsed time to fire after target detection by the tank commander (U).

results is that the variation in firing time for the first round is due to crew differences in the times required for the gunner to acquire the targets in his sights after target detection by the tank commander. The variation in firing time for the second round represents crew differences in the time required for the loader to reload the main gun. Therefore, gunnery accuracy would not necessarily be directly affected by differences in target acquisition and ranging, and reloading times.

(f) The mean gunnery scores and mean firing times for the companies were compared and are presented in figure 2-28.

Companies	Mean Gunnery Score	Mean Firing Time
A	992	8.20 seconds
C	933	8.71 seconds
B	828	10.40 seconds

Figure 2-28 (U). Mean gunnery and firing time scores (U).

The comparison presents evidence that a positive relation may exist between the scores and firing times. A faster firing rate is associated with a higher gunnery score. Analysis of accuracy scores with firing times, see section 2-3b(4)(e), indicated that slower firing times had no effect upon accuracy. Therefore, firing time performance must contribute indirectly to gunnery score by being considered as a measure of crew performance in the sub-tasks involved in gunnery; namely, the time required for target acquisition by the gunner in the target hand off task between the tank commander and gunner, and the time required for the loader to reload the main gun.

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(g) <u>Summary</u>. Tank crews of three companies of a 1st Cavalry
Division M60A1 tank battalion received a standardized gunnery training
program. Table VIII gunnery scores data for these tank crews was then
collected. Main gun scores were compared (analysis of variance) for
the tank companies for both day and night firings, and for both number
of hits and firing times required. Companies differed significantly
from each other both for targets hit ($p < .01$) and for firing times
required ($p < .001$). Since training was standardized, these differences
are attributed to company effects. The precise nature of these effects
is not known and should be the basis for further research.

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